Space Weather Technical Forecast

Issued on Friday, 03 March 2023 at 12:40 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Minor/Moderate R1/R2 radio blackouts. Risk of Minor Geomagnetic Storm G1 intervals, probably peaking later in UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with X-ray flares recorded at GOES16 mostly within C-class, but peaking with an M3.8 at 02/2116UTC, and an M3.3 at 03/1032UTC from sunspot region AR3234. The earlier event at least is likely to have been associated with a Coronal Mass Ejection (CME), with imagery pending for the later flare. The 03/1032UTC CME is not thought likely to carry an Earth-directed component at present, but will be analysed once imagery allows. This sunspot group was the largest and most complex of the nine on the current disc, showing apparent areal decay as it neared the northwestern solar horizon, and showing Ehi Zurich complexity and presumed persistence of its recent Beta-Gamma-Delta Mt Wilson configuration.

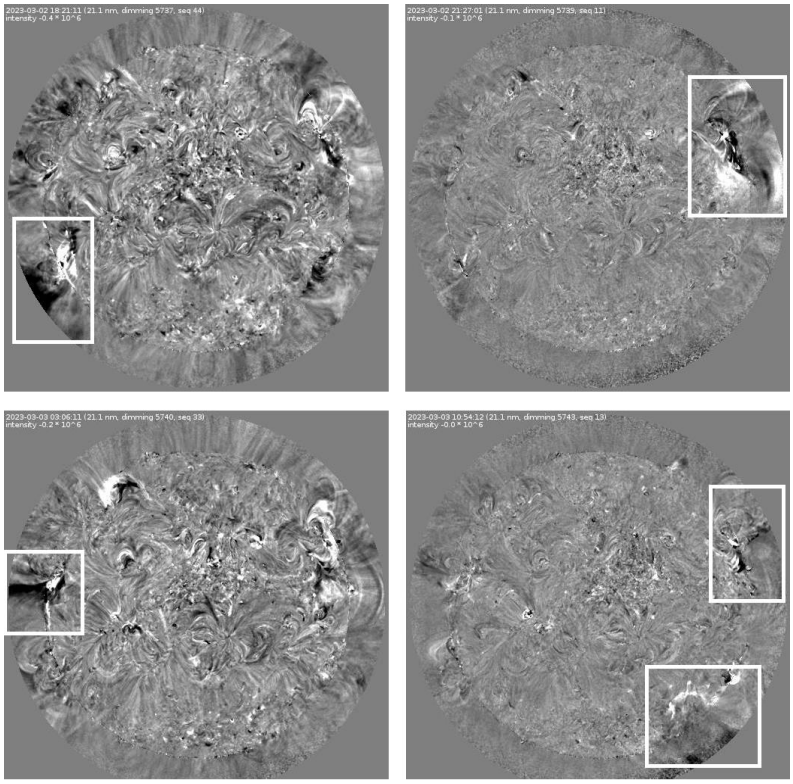

Figure 0: Rogues' gallery of a selection of potential CME-spawning events in the period, as they appear in time-integrated extreme UV imagery (processing courtesy of SIDC ROB). Note that they are all limbward.

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Also of note in terms of flares in the period was a C7.2 from newly-numbered AR3242, which showed as a Dhi/Beta, with a spreading tendency and fading of its trailing spots. This event is also considered likely to have produced a CME, with analysis also pending imagery.

Other regions on the disc mostly comprised small unipolar regions, with the possible main exception of newly-numbered AR3245 near the southeastern limb, which appears larger and bipolar given the limited scope to observe it in its current position.

As well as the aforementioned flares, other noteworthy CME progenitors in the period included a large prominence and filament eruption from the southeastern horizon, visible on El Teide H-Alpha imagery around 02/16-1700UTC. This appears to have taken the form of a slower and subsequent faster southeast-directed pair of CMEs. The slower of the pair has been analysed and is not likely to affect Earth, with thoughts for the latter provisionally similar. Also of note was a southwest quadrant filament eruption 03/07-0800UTC, visible on Learmonth H-Alpha imagery, which has also yet to be confirmed.

At present then, there are thought to be no new Earth-directed CMEs, although there is limited availability of confirming observations.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by DSCOVR and ACE, was likely connected to a negative polarity fast solar wind, with the phi angle accordingly negative (towards the Sun) throughout. The source of this activity is not certain, but may comprise a combination of fading CH79/- and perhaps also a faint west-pointing promontory from large and equatorial CH81/-. This is a possible reason for the observed re-intensification of the solar wind with no change of phi angle, although this is conjectural.

The solar wind speed initially fell from Elevated to Slightly Elevated levels in moving from 525 to a UTC evening nadir of 450km/s, before undergoing a resurgence to average around 575km/s by the period's end. The solar wind density was mostly at Background levels in single-figures ppcc, but did show a brief slight rise to nearer 10ppcc briefly immediately prior to the increase in solar wind speed in a possible very weak CIR, given CH81's presumed faster speed when compared to CH79. The IMF was relatively smooth in character, varying to a peak of 11nT around the time of the speed increase. The north-south component varied between +/-7nT, with an overall slight anti-aligned bias with Earth's field, especially in the later stages of Thursday 02 March.

The net effect of the above solar wind measures was for Quiet to Active geomagnetic activity, with provisional Kp peaks of '4-' roughly coincident with the main changes in the solar wind between 21 and 03UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 has been at Background levels.

Electron flux at GOES16 was initially above the High threshold, peaking at 3370pfu at 02/1715 UTC, but fell sharply as the new solar wind character developed and geomagnetic activity increased. Electron fluence started above the Active threshold (1e8 integrated flux), but with a declining trend then observed, crossing through 1.2e8 integrated pfu at 03/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a Chance of further Moderate activity, chiefly from AR3234 into the UTC weekend. This spot should depart by Sunday 05 March, leaving a tentative decrease in risk, although the sheer number of forecast arriving sunspot regions may arrest or even reverse this decline, with analysis of arrivals pending.

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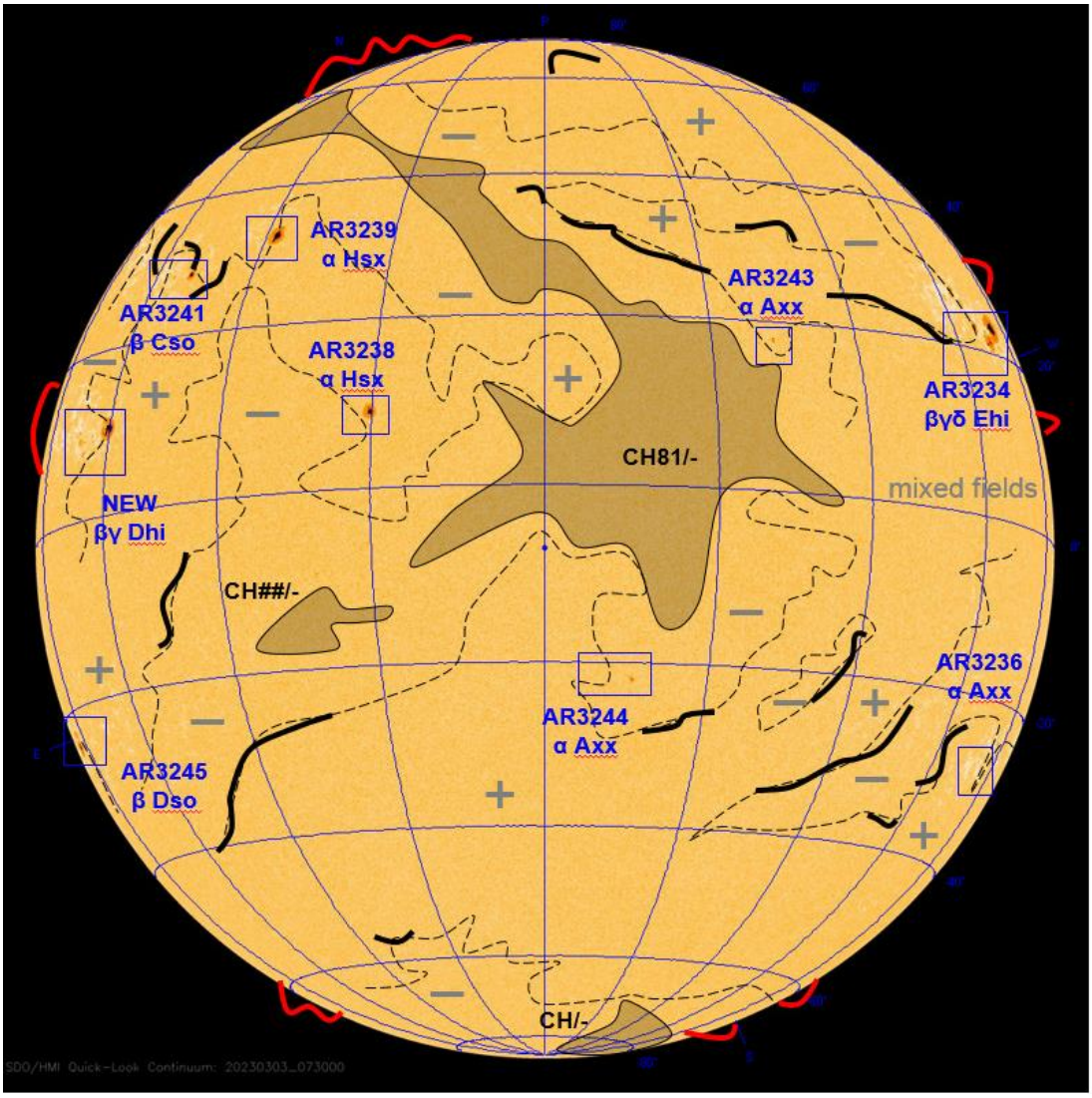
Solar Wind / Geomagnetic Activity: No Earth-directed CMEs feature in the forecast. Geomagnetic activity should therefore comprise of an exit from CH79 - possibly in course or complete - with likely more intense CH81 following. This gives a Slight Chance of G1 throughout, but peaking with a Chance on Sunday 05 March with the posited arrival of the most intense part of the coronal hole.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 2MeV) is at Background levels, but carries a peak Slight Chance of S1 or greater in the immediate term, given the recent M-class flare and the fact that AR3234 eventually rotates away from a peak geoeffective position into the new working week.

Electron flux is now considered likely to be suppressed given the recent resurgence in geomagnetic activity, but with a strong rebound eventually expected, with a Chance this could arrive during day four, Monday 06 March.

Figure 1. Solar Analysis Valid 03/0730UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No Earth-directed CMEs feature in the current forecast.

The geomagnetic forecast solely comprises of an imminent or perhaps completed departure from a recent negative polarity fast wind from CH79/-, segueing into a likely more intense fast wind from CH81/-. The fact that these holes share the same polarity may make any transition indistinct, which is why there is a suggestion that the process may have started given the recent resurgence in the solar wind speed.

While the bulk of this large and equator-spanning coronal hole remains just west of centre-disc, there is a possible faint promontory visible on AIA211 imagery that extends a day or two's rotation further west. This would help explain the earlier than anticipated arrival of a slight fast wind enhancement, although the bulk of any increase is still most likely to take place later in the UTC weekend.

Earth is currently very close to the March equinox, and as such negative polarity features ought to be maximally potent. Earth does in fact reach its maximum southward limit with respect to the solar equator at the very end of this four-day forecast, before undergoing a gradual six-month journey back northwards.

On last pass the analagous feature to CH81/- gave a protracted spell of Active and then Unsettled Kp, with a relatively higher risk of reaching G1 expected on this pass, probably front-loaded to the main and most intense portion of the coronal hole, probably still arriving on day three, Sunday 05 March, but with low confidence resulting in a smooth partitioning of this risk between UTC days.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	20	40	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

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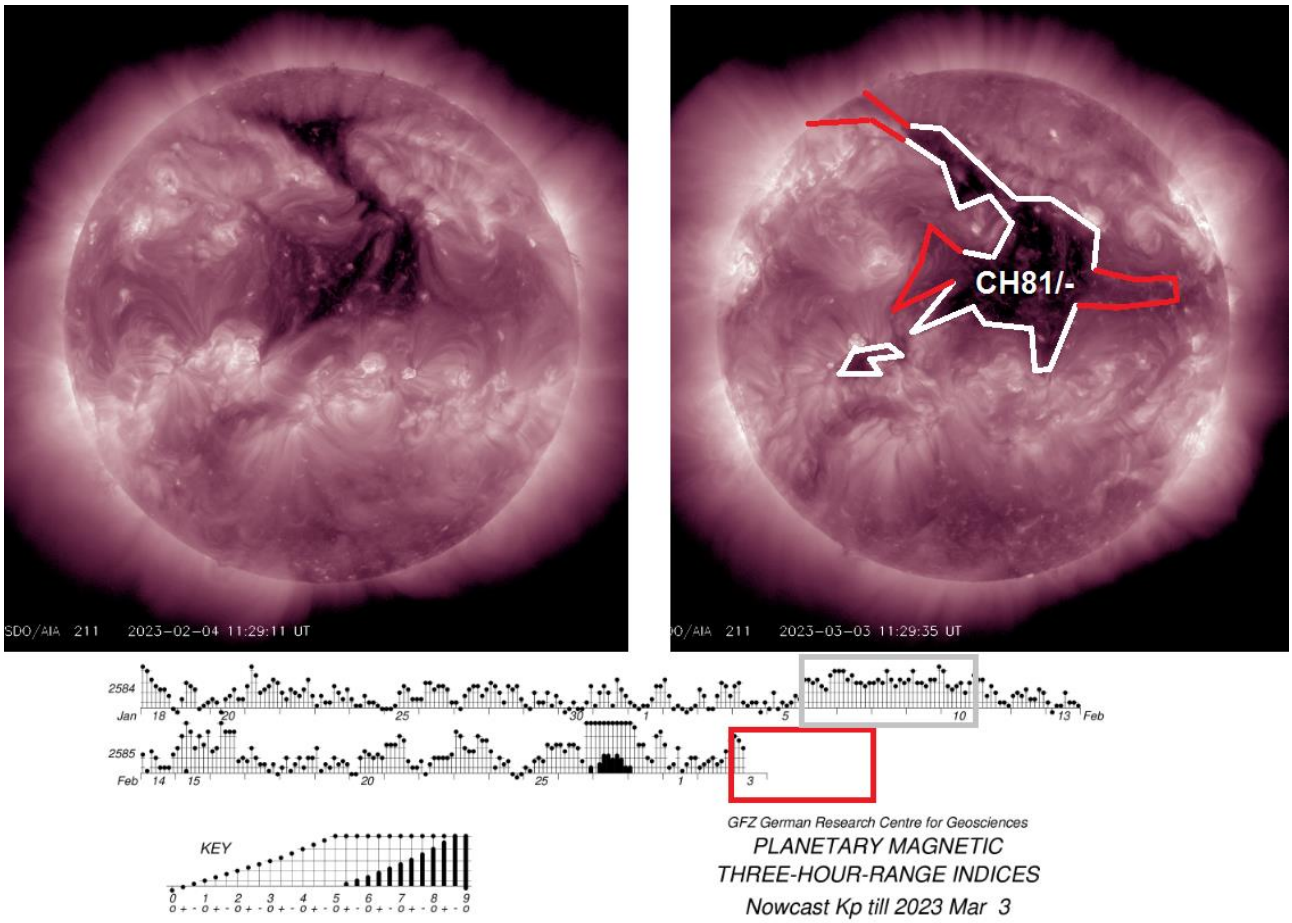
Figure 2: AIA211 imagery from the previous (left) and current (right) rotations, showing the analagous coronal hole to 81 and its current appearance. The more speculative portions of this feature have been coloured red. Below this is a Bartels music plot, showing the protracted period of Unsettled and peak Active Kp seen on last pass (grey box), with slightly greater activity possible on this rotation (forecast period in red box), with the possible current early arrival perhaps the result of the westernmost red portion of CH81 in the upper right image.


SDO/AIA 211 2023-02-04 11:29:11 UT
CH81/-
O/AIA 211 2023-03-03 11:29:35 UT
2584
Jan 18 20 25 30 1 5 10 13 Feb
2585
Feb 14 15 20 25 1 3
KEY
0 1 2 3 4 5 6 7 8 9
GFZ German Research Centre for Geosciences
PLANETARY MAGNETIC
THREE-HOUR-RANGE INDICES
Nowcast Kp till 2023 Mar 3

Radio Blackouts - X-Ray Flares:

AR3234 is currently the largest and most active region on the disc, producing a pair of M-class flares in the past 24 hours. This group is apparently fading in recent observations, but this is thought likely to at least in part be an artefact of its narrowing viewing angle as it near the northwestern solar horizon. It is no longer possible to definitively identify its Mt Wilson Delta spot(s), however they are suspected to persist in light of recent flares. This group should cross the northwestern limb inside the next 36 hours and should result in a downward step-change in flare risk, although confidence in this decreasing risk assertion is low.

The rationale for the low confidence is a cluster of returning Carrington locations for as many as eleven due sunspot regions massing behind the eastern limb. Their survival of their far-side crossing and their contribution to any risk increase into the coming new UTC week is not assured, however. For this reason, no definitive rallying or rising of the flare risk is suggested for the eastern limb groups yet, although given the sheer number of spots expected at least some ought to contribute.

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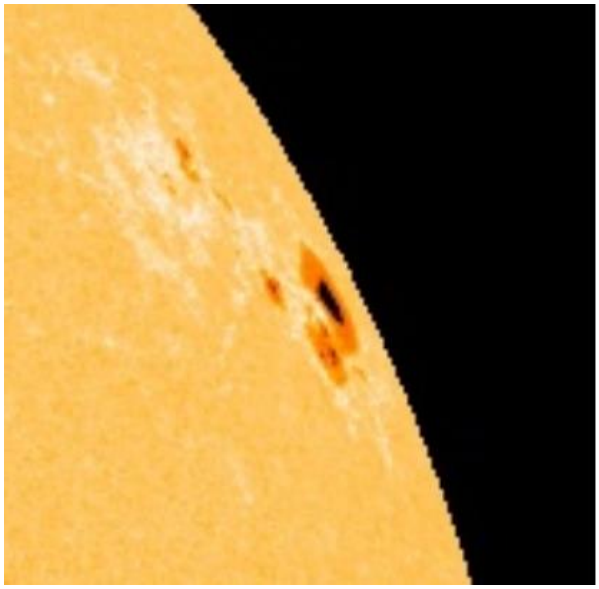
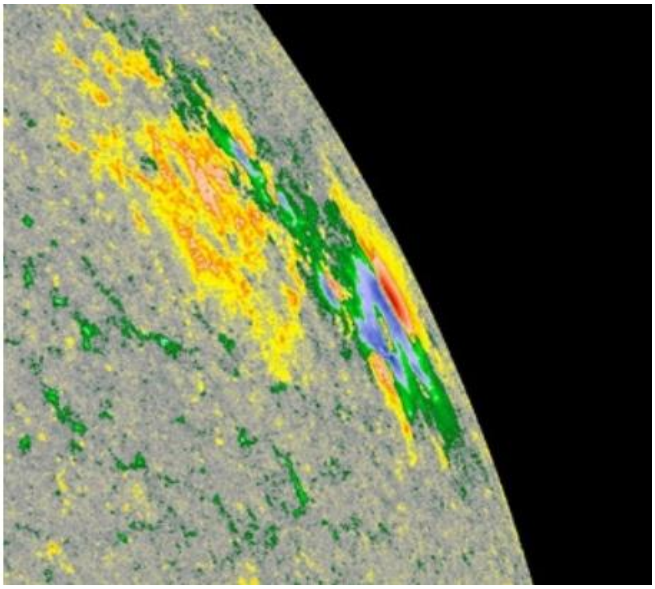
X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	40	40
Very Active	R3 to R5 X Class	No	10	10	5	5

Figure 3: 03/1130UTC HMIIF and HMIBC imagery of AR3234 in the northwest. The containing plage is likely to be concealing detail given the narrowing viewing angle.





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Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, is at background levels. Although S1 radiation storms have not occurred with recent M-class flares, the fact that the latest M3.3 occurred so close to the issue of this guidance implies there is at least a slightly increased chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 10% into the UTC weekend. Dominating this risk is AR3234, which will continue to present a gradually fading risk as the region rotates off behind the western limb.

While yet to appear, the numerous arriving eastern hemisphere spots due in the period should not appreciably contribute to the risk of S1 or greater until later next week.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	10	10	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The recent resurgence in the solar wind speed and arrival of Active geomagnetic activity has greatly reduced the flux at GOES16 - falling from High flux to Normal Background. This may be the vanguard of the main CH81/- fast wind, with this tentatively maintained as a most likely arrival in day three, Sunday 05 March, although now with reduced confidence.

Much of this period should therefore be characterised by Unsettled or Active geomagnetic activity, which ought to continue to suppress electron counts at GEO, however a strong rebound is likely into the new working week, perhaps beginning as early as day four, Monday 06 March to give a peak Chance of Active 24-hour integrated fluence for the period.

MOSWOC REFM now shows a suppressed forecast for the next 72 hours, which is accepted, although its range falls short of the more speculative increase due around day four.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	20	20	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	10

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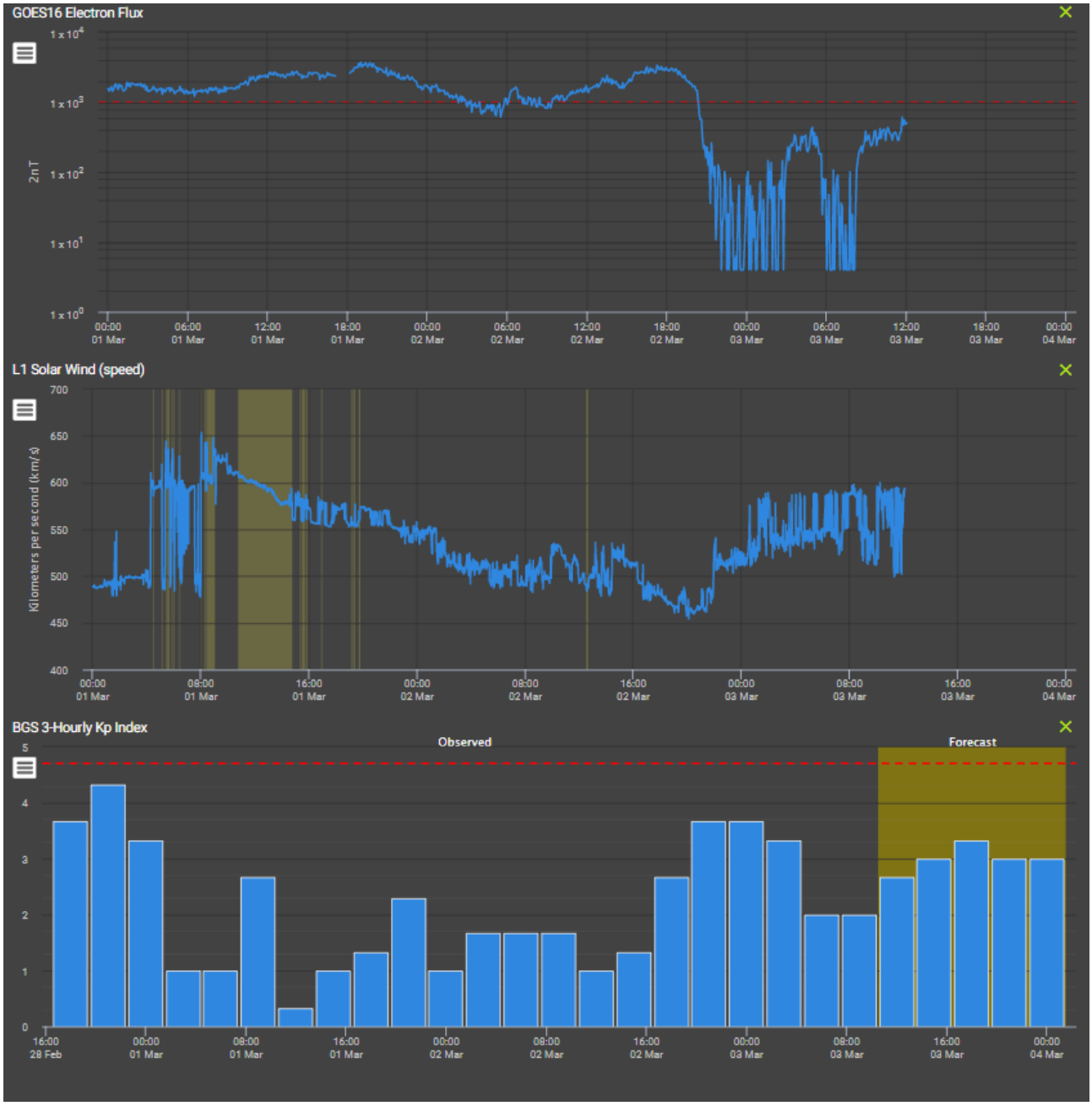
Figure 4: Top to bottom: three-day GOES16 electron flux; L1 solar wind at ACE and DSCOVR; BGS Kp indices. The current geomagnetic enhanecements are now expected to largely continue for the majority of the forecast period.



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